Geotechnical Engineering Report

Red Lodge Campground Improvements
Cooney State Park
Near Boyd, Montana
January 17, 2013
Terracon Project No. 26125086

MONTANA
MATTHEW R. GEERING
No. 17038 PE
LICENSED
PROFESSIONAL ENGINEER

Prepared for:
Sanderson Stewart
Bozeman, Montana

Prepared by:
Terracon Consultants, Inc.
Billings, Montana

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January 17, 2013

Terracon

Sanderson Stewart
106 East Babcock
Bozeman, Montana 59715

Attn: Ms. Danielle Scharf, PE, PTOE, LEED AP
Associate/Senior Engineer
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Re: Geotechnical Engineering Report
Red Lodge Campground Improvements
Cooney State Park
Near Boyd, Montana
Terracon Project Number: 26125086

Dear Ms. Scharf:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number D2612232. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and gravel surfacing for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

FOR

Andrew Foster, E.I.
Staff Geotechnical Engineer

Matt Geering, P.E.
Geotechnical Department Manager

Reviewed by: Walt Feeger, P.E.

Enclosures
cc: 3 - Client
1 – File

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EXECUTIVE SUMMARY

A geotechnical investigation has been performed for the proposed Red Lodge Campground Improvements project to be located at Cooney State Park near Boyd, Montana. Four (4) borings, designated B-1 to B-4, were performed to depths of approximately 16.5 feet below existing grades at the project site.

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed project consistent with the recommendations provided in this report. The following geotechnical considerations were identified:

- Based on materials encountered in our borings, underlying a layer of topsoil, the subsurface profile generally consists of sandy lean clay overlying silty sand with gravel. The sand soils varied in depth and were encountered at approximate depths ranging from 1.5 to 16 feet below the existing grades. The sand soils extended to the end of the borings in B-2 to B-4. Sedimentary bedrock was encountered in Boring B-1 at an approximate depth of 9 feet below existing grade.

- In our opinion, concrete slabs should be supported by a zone of 4 to 6 inches of gravel base over 8 inches of reconditioned native soil.

- A gravel surfacing section of at least 12 inches is recommended over 8 inches of reconditioned native soil.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
RED LODGE CAMPGROUND IMPROVEMENTS
NEAR BOYD, MONTANA

Terracon Project No. 26125086
January 17, 2013

1.0 INTRODUCTION

A geotechnical investigation has been performed for the proposed Red Lodge Campground Improvements project to be located at Cooney State Park near Boyd, Montana. Four (4) borings, designated B-1 to B-4, were performed to depths of approximately 16.5 feet below the existing grades at the project site. Logs of the borings along with a boring location diagram are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- soil and groundwater conditions
- site and subgrade preparation
- gravel surfacing thickness design
- utility trench considerations
- general earthwork and drainage

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Improvements	The project consists of improvements to the Red Lodge Campground involving development of a new camping loop and extending an existing loop, including; gravel roads, campsites, landscaping, latrine installation, campground host pad(s) and utilities.
Grading	Unknown at this time. Cuts and fills are anticipated to be within ±2 feet of existing site grades.
Cut and fill slopes	Assumed to be no steeper than 3H:1V if required.

Terracon

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	The proposed project is located at the Red Lodge Campground situated along Red Lodge Creek Road on the south shore of Cooney Reservoir in Cooney State Park near Boyd, Montana. (Approx. coordinates: N 45° 26' 27.21", W 109° 13' 58.17")
Existing improvements	The site currently consists of an existing campground.
Current ground cover	Native vegetation.
Existing topography	Slight drainage to the north towards the reservoir.

3.0 SUBSURFACE CONDITIONS

3.1 Soil Conditions

Based on materials encountered in our borings, underlying a layer of topsoil, the subsurface profile generally consists of sandy lean clay overlying silty sand with gravel. The sand soils varied in depth and were encountered at approximate depths ranging from 1.5 to 16 feet below the existing grades. Clayey sand was encountered in boring B-4 at an approximate depth of 9 feet overlying silty sand with gravel. The sand soils extended to the end of the borings in B-2 to B-4.

Bedrock was encountered in Boring B-1 at an approximate depth of 9 feet below the existing grade. The sedimentary bedrock was classified as sandstone with weak cementation, highly weathered and soft.

Conditions encountered at each boring location are indicated on the individual logs found in Appendix A of this report. Stratification boundaries on the logs represent the approximate location of changes in soil; in situ, the transition between materials may be gradual.

3.2 Soil Properties

The lean clay soils had Standard Penetration Test (SPT) N-values in the range of 10 to 50 blows per foot. This indicates these soils are variably stiff to hard in consistency, have low compressibility, and low to moderate shear strength characteristics. The SPT N-values in the sand soils ranged from 5 to 50+ blows per foot, with blows typically greater than 10. This wide range indicates the sands to be loose to very dense in relative density with relatively low compressibility and moderate to high shear strength characteristics.

The fine grained soils encountered in the borings were of low plasticity and had the following liquid limit, plastic limit, plasticity index and percent fines:

Location	Depth (ft)	Material	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Percent Fines (%)
Boring B-2	5.0	CL	24	15	9	54
Boring B-4	10.0	SC	25	14	11	47

Representative samples of the subgrade soils were collected for Moisture-Density Relationship (Standard Proctor, ASTM D698) testing (See Moisture Density Relationship in Appendix B). The results are summarized in the following table:

Location	Depth (ft)	Material	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
Boring B-1	1.5-5.0	SM	139.2	7.4
Borings B-2 & B-4	1.0-6.0	CL	120.6	11.3

3.3 Groundwater

The borings were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in the borings while drilling, or for the short duration that the borings were allowed to remain open.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structures may be higher or lower than the levels indicated on the logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the subsurface exploration and laboratory test results, we recommend the proposed improvements be supported by a zone of reconditioned native soil. A zone of at least eight (8) inches of scarified and re-compacted native soils is recommended to provide base support for proposed slabs and gravel surfacing.

4.2 Earthwork

Earthwork on the project should be observed and evaluated by Terracon. Contractor methods and equipment can make substantial differences in the success of earthwork and excavation operations; our recommendations have been developed based on our investigation findings and what we believe to be standard construction practices and capabilities in the project area. The evaluation of earthwork should include subgrade preparation, gravel surfacing compaction, and other geotechnical conditions involved with construction of the project.

4.2.1 Subgrade Preparation

Existing vegetation, topsoil and other unsuitable materials (e.g. debris, desiccated soil, frozen soil, etc.) should be removed from the proposed construction areas. It is anticipated that general excavations for the proposed construction can be accomplished with conventional earthmoving equipment such as tractor mounted backhoes and tracked excavators.

The excavated site soils, cleaned of all organic/deleterious material, construction debris, and rock greater than 3 inches in nominal size (if encountered), may be stockpiled on-site and re-used for landscaping purposes. The site soils were typically below the optimum moisture levels at the time of the investigation. Due to this, wetting of the site soils may be necessary depending on the construction season.

In order to provide a stable base for improvements, we recommend scarification and re-compaction of at least eight (8) inches of native soil prior to gravel and/or concrete placement. Within the proposed areas to receive gravel surfacing, scarification, moisture conditioning, and re-compaction of the clay subgrade soils is recommended. Subgrade soils beneath gravel surfacing areas should be scarified to a depth of at least 8 inches, moisture conditioned to within 3 percent of optimum and compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D698. The moisture content and compaction of subgrade soils should be maintained until gravel placement.

4.2.2 Material Requirements

It is anticipated that excavated materials will be used to the extent practical as landscaping or general fill. The material suitability should be evaluated by the geotechnical engineer prior to use. Moisture conditioning and processing of on-site soils will likely be required.

Fill Type	USCS Classification	Acceptable Location for Placement
On-site soils[1]	CL, SM	Below slabs, backfill, lot fill and landscaping
Open-graded drainage aggregate[2]	GP	Below slabs (4" - 6")

1. Moisture conditioning of the native soils will likely be required; this could often involve mechanical reduction in size (disking, etc.) which may be difficult during wet/cold seasons.
2. 3/8" to 3/4" crushed, open-graded aggregate comprised of durable gravel or rock particles.

4.2.3 Compaction Requirements

Item	Description
Fill Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used. 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used.
Minimum Compaction Requirement[1] (ASTM D698)	**Scarified subgrade soils:** 95% **Aggregate base (beneath slabs):** 95% **Wall/Trench backfill:** 95% **Miscellaneous backfill (non-structural areas):** 90%
Moisture Content (ASTM D698)	±3% of optimum

1. We recommend that each lift of fill be tested by Terracon for moisture content and compaction prior to the placement of additional material. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested until the specified moisture and compaction requirements are achieved.

4.2.4 Surface Grading and Drainage

Positive drainage should be provided during construction and maintained throughout the life of the proposed project. Infiltration of water into excavations must be prevented during construction. All grades should provide effective drainage during and after construction. Water permitted to pond can result in soil movements. These movements can result in unacceptable differential settlements, and cracked slabs.

4.2.5 Construction Considerations

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of slabs and gravel surfacing. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and re-compacted prior to floor slab and pavement construction.

The geotechnical engineer and/or their representative should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation including excavation methods, placement and compaction of fills, and backfilling of excavations to ascertain reasonable compliance with our recommendations and their intent.

4.2.6 Utility Trench Considerations

Excavations will encounter a variety of conditions depending on the depth of excavations. Shallow sandy lean clay soils were encountered over sand and gravel soils overlying sedimentary bedrock.

Based on conditions encountered during our field testing, excavations should be relatively stable and dry. However, unfavorable subsurface conditions could exist depending on seasonal conditions. Typically, sand and gravel soils are susceptible to caving especially in the presence of high groundwater. If unstable subgrade soils are encountered, remediation may be required to create a working platform prior to utility placement. As a safety measure, vehicles and stockpiles should be kept away from the excavation crest a distance at least equal to the slope height. Surface drainage should be directed away from the excavation.

The soil classifications shown on the logs are based solely on the materials encountered in the borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered during construction, the actual conditions should be evaluated by the contractor's competent person to determine any excavation modifications necessary to maintain safe conditions. As a minimum, all temporary excavations should be sloped or braced, as required by Occupational Health and Safety Administration (OSHA) regulations, to provide stability and safe working conditions. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations, as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Depending on the depths of excavations and subsurface conditions, the use of temporary shoring and/or trench boxes will likely be required. Shoring design should be conducted by a registered engineer based on the available subsurface information verified by observation of actual excavation conditions.

Should trench bottom conditions require stabilization for proper utility support, the use of "stabilization gravel" with a geotextile wrap should be considered to provide utility foundation based on observations and recommendations by our geotechnical engineer. Stabilization gravel should be an open-graded material with 5 percent or less passing the number 200 sieve. Only light weight compaction equipment should be used to compact the first foot of bedding and/or backfill above the trench bottom.

The excavated materials will generally be suitable for use as trench backfill above the utility bedding. However, the consistency and the natural moisture content of the soils will likely vary across the project. It is likely that most areas will require the addition of moisture.

Based on the moisture-density relationship (proctor) tests, the near surface soils are generally below the optimum moisture content. Earthwork contractors should anticipate processing and moisture conditioning the site soils prior to use as backfill material.

4.4 Exterior Slab Construction Considerations

Exterior slabs-on-grade founded on the site clay soils can experience movement due to the potential volume change of the material. This movement could present hazards where slab sections move independently. With respect to our recommendations presented in this report, potential movement can also be reduced by:

- Performing regular joint-sealing maintenance
- Minimizing moisture introduction to slab surfaces
- Controlling moisture-density during placement
- Placing effective control joints on relatively close centers

4.5 Corrosion Protection

Soil samples were submitted for soluble sulfate, pH and electrical resistivity testing. The results are summarized in the following table:

Location	Depth (ft)	Material	Soluble Sulfate Content (%)	Resistivity (ohm-cm)	pH
Boring B-1	1.0-5.0	SM	<0.01	1,610	7.2
Borings B-2 & B-4	1.0-5.0	CL	<0.01	1,470	7.8

Soluble sulfate values from 0.00 to 0.10 are considered to have negligible attack on normal strength concrete. As a result, Type I Portland cement can be specified for all project concrete. However, if additional protection in this regard is desired, Type II cement should be specified. Foundation concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

Resistivity values within the range of 1,000 to 3,000 are considered to be strongly aggressive with regard to corrosion of buried metals. If corrosion of buried metal is critical, it should be protected using a non-corrosive backfill, wrapping, coating, sacrificial anodes, or a combination of these methods, as designed by a qualified corrosion engineer.

4.6 Gravel Surfacing Design

4.6.1 Design Considerations

Gravel surfacing section alternatives for this project were designed based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO).

For purposes of this design analysis, a terminal serviceability index of 2.0, an inherent reliability of 80 percent, and a subgrade drainage coefficient of 0.9 were used. It is anticipated that surfacing subgrade soils will consist of clay soils which are typically considered poor materials for pavement support. A correlated California Bearing Ratio (CBR) value of 3.0 was used in the design analysis based on our experience with similar soil types. Please note that this CBR value and the surfacing section alternatives provided assume that the site clay soils will be re-compacted and left in-place within the surfacing areas. If this is not the case, Terracon should be notified to provide additional gravel surfacing design recommendations based on the subgrade soils which will be present below the surfacing sections.

Specific traffic data was not provided for this project. Therefore, we have assumed an equivalent 18-kip single axle load (ESAL) of 30,000 to represent the design traffic intensity for the proposed parking and access over a 20-year design period. Please notify us if any of the parameters used in the design do not adequately define the anticipated conditions.

Aggregate base course should consist of a blend of sand and gravel which meets MPW specifications for quality and gradation. Aggregate base course should be compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D 698.

The section presented herein is based on design parameters selected by Terracon based on experience with similar projects and soil conditions. Design parameters may vary with the specific project and material source. Variation of these parameters may change the thickness of the gravel surfacing section presented. Terracon is prepared to discuss the details of these parameters and their effects on gravel surfacing design and reevaluate the design as appropriate.

4.6.2 Minimum Gravel Surfacing Thickness

Typical Pavement Section Thicknesses	
Traffic Area	**Gravel Surfacing, inches**
Parking & Access	12

This section is based on design traffic operated on the finished section. Construction use of the section or partial components thereof for support of excessive or channelized wheel loads may lead to rutting or failure. Properly compacted materials and prudent selection of compaction, hauling, and construction equipment will be necessary to preserve the integrity of the subgrade and gravel surfacing components during construction.

4.6.3 Drainage & Maintenance

Surfacing should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the surfacing could saturate the subgrade and contribute to premature deterioration. In addition, the subgrade should be graded to provide positive drainage.

The section provided in this report represents minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going management program. Preventive maintenance activities are intended to slow the rate of deterioration and to preserve the investment. Preventive maintenance is usually the first priority when implementing a planned maintenance program and provides the highest return on investment. Prior to implementing any maintenance program, additional engineering input is recommended to determine the type and extent of preventive maintenance appropriate. Even with periodic maintenance, some movements may still occur and repairs may be required.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include, either specifically or by implication, any environmental or biological (e.g., petroleum hydrocarbons, mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

APPROXIMATE LOCATION OF BORING. Not a Legal Survey All Boring Locations Approximate	Project Mngr: MG Drawn By: AF Checked By: GR Approved By: MG	Project No. 26125086 Scale: As Shown File No. Boring Location Diagram.dwg Date: January 2013	Terracon Consulting Engineers and Scientists 2110 Overland Avenue, Ste. 124 Billings, Montana PH. (406) 656-3072 FAX. (406) 656-3578	BORING LOCATION DIAGRAM Red Lodge Campground Improvements Red Lodge Campground - Cooney State Park Boyd, Montana	FIG No A-1

BORING LOG NO. B-1

PROJECT: Red Lodge Campground Improvements

CLIENT: Sanderson Stewart Billings, Montana

SITE: Cooney State Park Near Boyd, Montana

LOCATION See Exhibit A-1

Latitude: 45.44130232° Longitude: -109.24

Surface Elev.: 4263.04 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**TOPSOIL**, brown, frost encountered	4262.5									
1.5	**SANDY LEAN CLAY**, light brown	4261.5				1.2	5-20-30 N=50	7			
	SILTY SAND WITH GRAVEL, light brown to brown, very dense					0.4	50/5" N=50/5"	2		NP	13
9.0		4254	5			1	24-50/6" N=50/6"	3			
	SEDIMENTARY BEDROCK - SANDSTONE, light brown to brown, weak cementation, fine to medium grained, highly weathered, soft, interbedded carbonaceous shale and siltstone		10			1	5-8-19 N=27	15			
16.0		4247	15			1	24-50/6" N=50/6"	12			
	Boring Terminated at 16 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-6 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevation provided by Sanderson Stewart

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 12/11/2012	Boring Completed: 12/11/2012
Drill Rig: CME 55	Driller: T. Miller
Project No.: 26125086	Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 26125086 COONEY.GPJ TERRACON2012.GDT 1/17/13

BORING LOG NO. B-2

PROJECT: Red Lodge Campground Improvements

CLIENT: Sanderson Stewart, Billings, Montana

SITE: Cooney State Park, Near Boyd, Montana

LOCATION See Exhibit A-1

Latitude: 45.44027859° Longitude: -109.2364873°

Surface Elev.: 4274.31 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**TOPSOIL**, brown, frost encountered	4274									
	SANDY LEAN CLAY (CL), light brown to brown, stiff				X	1.2	4-7-6 N=13	8			
					X	1.5	8-7-7 N=14	6			
			5		X	1.5	7-8-7 N=15	4		24-15-9	54
			10		X	1.5	4-4-6 N=10	9			
			15		X	1.5	3-6-11 N=17	9			
16.2		4258									
16.5	**SILTY SAND WITH GRAVEL (SM)**, brown, medium dense	4258									
	Boring Terminated at 16.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-6 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevation provided by Sanderson Stewart

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 12/11/2012	Boring Completed: 12/11/2012
Drill Rig: CME 55	Driller: T. Miller
Project No.: 26125086	Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 26125086 COONEY.GPJ TERRACON2012.GDT 1/17/13

BORING LOG NO. B-3

PROJECT: Red Lodge Campground Improvements

SITE: Cooney State Park
Near Boyd, Montana

CLIENT: Sanderson Stewart
Billings, Montana

LOCATION See Exhibit A-1

Latitude: 45.44023052° Longitude: -109.233732°

Surface Elev.: 4267.87 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**TOPSOIL**, brown, frost encountered	4267.5								
	SANDY LEAN CLAY (CL), light brown					3-11-15 N=26	8			
2.0		4266								
	SILTY SAND WITH GRAVEL (SM), light brown to brown, medium dense					7-6-4 N=10	5			
			5			4-5-6 N=11	5			
			10			3-6-6 N=12	5			
15.0		4253	15							
	Boring Terminated at 15 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid flight

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-6 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevation provided by Sanderson Stewart

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 12/11/2012	Boring Completed: 12/11/2012
Drill Rig: CME 55	Driller: T. Miller
Project No.: 26125086	Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 26125086 COONEY.GPJ TERRACON2012.GDT 1/17/13

BORING LOG NO. B-4

PROJECT: Red Lodge Campground Improvements

CLIENT: Sanderson Stewart, Billings, Montana

SITE: Cooney State Park, Near Boyd, Montana

LOCATION See Exhibit A-1

Latitude: 45.44019393° Longitude: -109.2483287°

Surface Elev.: 4262.85 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**TOPSOIL**, brown, frost encountered	4262.5									
	SANDY LEAN CLAY (CL), light brown to brown, stiff				X	1.2	6-6-7 N=13	9			
					X	1.5	7-6-6 N=12	4			
			5		X	1.5	3-4-10 N=14	5			
9.0		4254									
	CLAYEY SAND (SC), brown, medium dense		10		X	1.5	4-7-5 N=12	10		25-14-11	47
11.0		4252									
	SILTY SAND WITH GRAVEL (SM), brown, loose to medium dense		15		X	1	3-2-3 N=5	6			
16.5		4246.5									
	Boring Terminated at 16.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid flight

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-6 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevation provided by Sanderson Stewart

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 12/11/2012 | Boring Completed: 12/11/2012

Drill Rig: CME 55 | Driller: T. Miller

Project No.: 26125086 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 26125086 COONEY.GPJ TERRACON2012.GDT 1/17/13

Field Exploration Description

The boring locations were laid out on the site by Sanderson Stewart personnel with guidance from Terracon. Elevations were provided by Sanderson Stewart. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a CME 55 rotary drill rig using hollow-stem and solid flight augers to advance the boreholes. Samples of the soils encountered in the borings were obtained by driving split spoon samplers and collecting auger cuttings.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils.

A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings and patched with asphalt cold patch prior to the drill crew leaving the site.

Field logs were prepared by the field engineer. The logs included visual classifications of the materials encountered during drilling as well as the engineer's interpretation of the subsurface conditions between samples. The final logs included with this report represent the engineer's interpretation of the field logs and includes modifications based on laboratory observations and tests of the samples.

Laboratory Testing

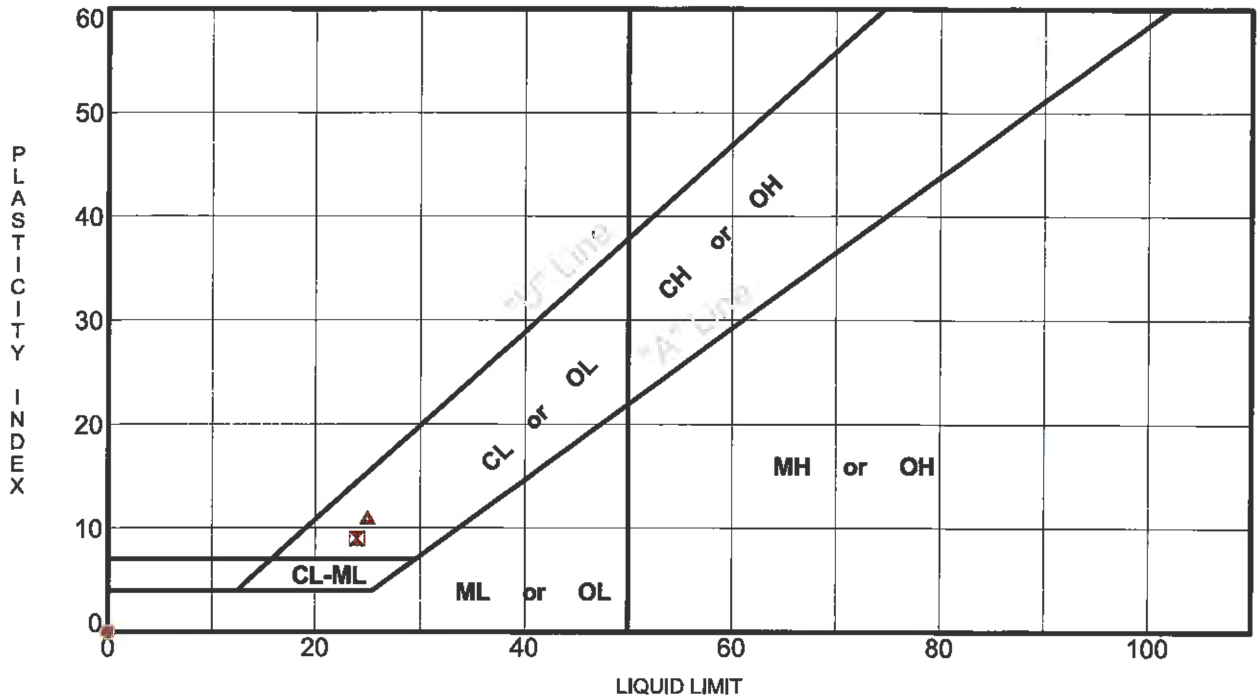
As a part of the laboratory testing program, the soil samples were classified in the laboratory based on visual observation, texture, plasticity, and the laboratory testing performed as noted below. The soil descriptions presented on the boring logs are in accordance with our enclosed General Notes and Unified Soil Classification System (USCS). The estimated group symbol for the USCS is also shown on the logs, and a brief description of the Unified System is included in this report. Results of the laboratory tests are presented on the logs and/or included herein.

Selected soil samples were tested for the following properties:

- Water Content
- Grain Size Distribution
- Atterberg Limits
- Moisture/Density Relationship
- Water Soluble Sulfate, pH, & Resistivity

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
B-1	2.5	NP	NP	NP	13	SM	SILTY SAND with GRAVEL
B-2	5.0	24	15	9	54	CL	SANDY LEAN CLAY
B-4	10.0	25	14	11	47	SC	CLAYEY SAND

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 26125086 COONEY.GPJ TERRACON2012.GDT 1/16/13

PROJECT: Red Lodge Campground Improvements

SITE: Cooney State Park Near Boyd, Montana

Terracon

2110 Overland Ave., Suite 124 Billings, Montana

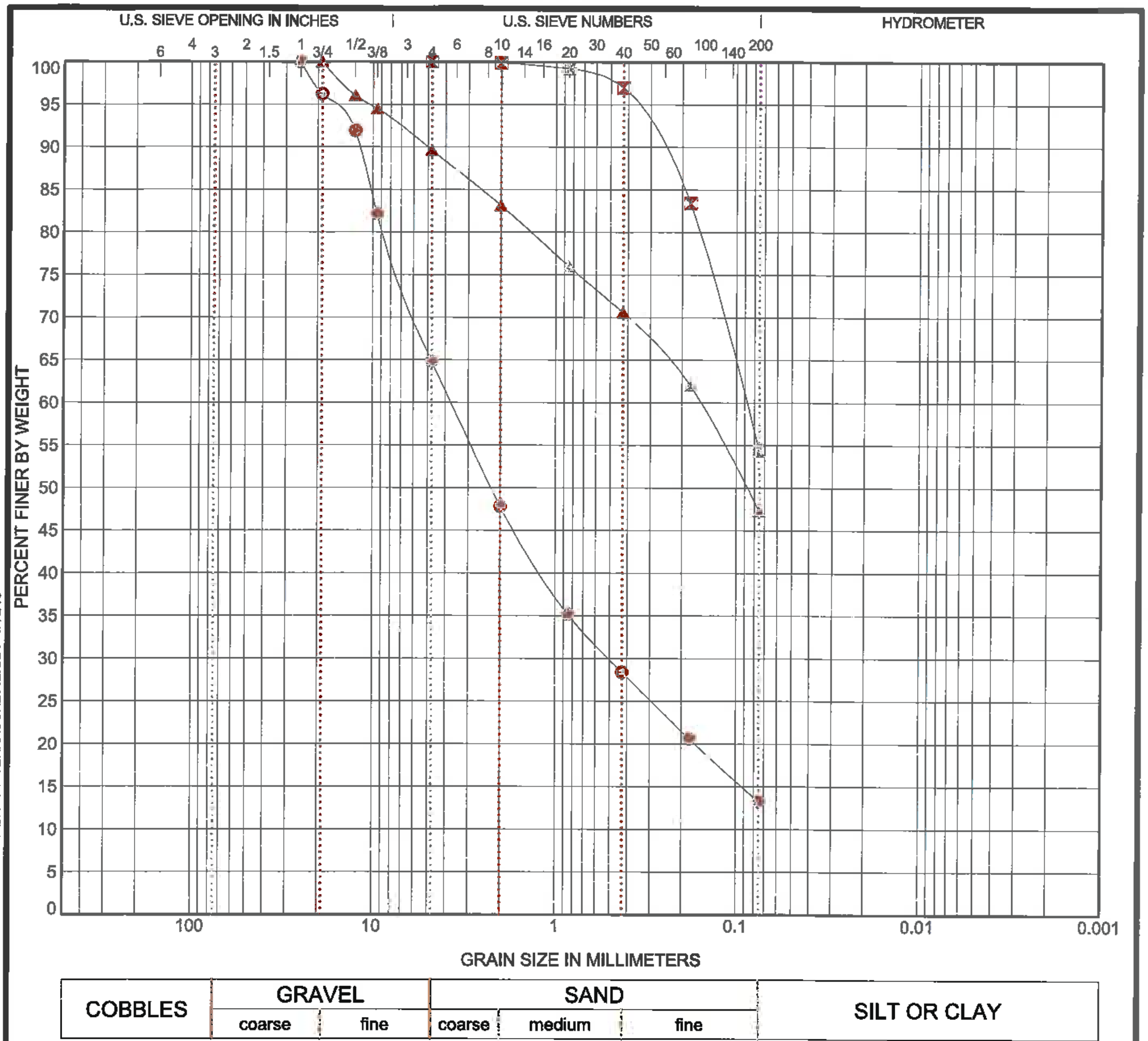
PROJECT NUMBER: 26125086

CLIENT: Sanderson Stewart Billings, Montana

EXHIBIT: B-2

GRAIN SIZE DISTRIBUTION

ASTM D422



	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	B-1	2.5	SILTY SAND with GRAVEL(SM)	NP	NP	NP		
⊠	B-2	5.0	SANDY LEAN CLAY(CL)	24	15	9		
▲	B-4	10.0	CLAYEY SAND(SC)	25	14	11		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	B-1	2.5	25	3.714	0.501		35.2	51.6	13.3	
⊠	B-2	5.0	4.75	0.089			0.0	45.6	54.4	
▲	B-4	10.0	19	0.159			10.4	42.3	47.3	

PROJECT: Red Lodge Campground Improvements

SITE: Cooney State Park
Near Boyd, Montana

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

PROJECT NUMBER: 26125086

CLIENT: Sanderson Stewart
Billings, Montana

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 26125086 COONEY.GPJ TERRACON2012.GDT 1/16/13

Terracon
2110 Overland Avenue, Suite 124
Billings, MT 59102
(406) 656-3072 FAX: (406) 656-3578

LABORATORY COMPACTION CHARACTERISTICS OF SOIL

CLIENT NAME:	Sanderson Stewart
PROJECT NAME & LOCATION:	Red Lodge Campground Improvements, Cooney State Park, Montana
PROJECT NO.:	26125086
SOURCE MATERIAL:	B-1 @ 1.5'-5'
SAMPLE DESCRIPTION:	SILTY SAND WITH GRAVEL
MATERIAL DESIGNATION:	
TEST METHOD:	D698
TEST PROCEDURE:	C
SAMPLE PREPARATION:	Dry

DATE: 12/14/12 LAB No. 9988
REPORT NO.:

TEST RESULTS

MAXIMUM DRY DENSITY	139.2	lb/ft3
OPTIMUM MOISTURE	7.4	%

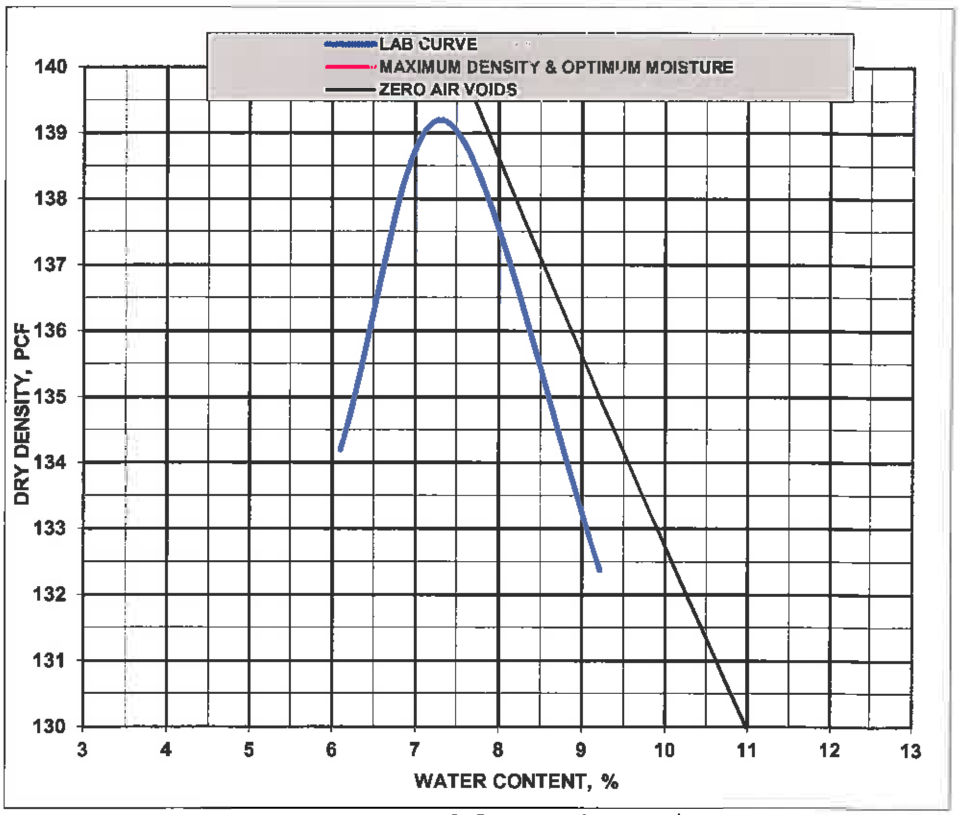
RAMMER: MANUAL Mechanical

ATTERBERG LIMITS

LIQUID LIMIT	NP
PLASTIC LIMIT	NP
PLASTICITY INDEX	NP

REVIEWED BY:

ZERO AIR VOIDS FOR SPECIFIC GRAVITY OF 2.70



Corrected for 12.8% Oversize

EXHIBIT: B-4

Terracon

2110 Overland Avenue, Suite 124
Billings, MT 59102
(406) 656-3072 FAX: (406) 656-3578

LABORATORY COMPACTION CHARACTERISTICS OF SOIL

CLIENT NAME:	Sanderson Stewart
PROJECT NAME & LOCATION:	Red Lodge Campground Improvements Cooney State Park, Montana
PROJECT NO.:	26125086
SOURCE MATERIAL:	B-2 & B-4 @ 1'-6'
SAMPLE DESCRIPTION:	SANDY LEAN CLAY
MATERIAL DESIGNATION:	
TEST METHOD:	D698
TEST PROCEDURE:	B
SAMPLE PREPARATION:	Dry

DATE:	12/14/12	LAB No.	9989
REPORT NO.:			

TEST RESULTS

MAXIMUM DRY DENSITY	120.6	lb/ft3
OPTIMUM MOISTURE	11.3	%
RAMMER:	MANUAL	Mechanical

ATTERBERG LIMITS

LIQUID LIMIT	24
PLASTIC LIMIT	15
PLASTICITY INDEX	9
REVIEWED BY:	

ZERO AIR VOIDS FOR SPECIFIC GRAVITY OF 2.68

EXHIBIT: B-5

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING		WATER LEVEL		FIELD TESTS	
Auger	Split Spoon	Water Initially Encountered		(HP)	Hand Penetrometer
Shelby Tube	Macro Core	Water Level After a Specified Period of Time		(T)	Torvane
Ring Sampler	Rock Core	Water Level After a Specified Period of Time		(b/f)	Standard Penetration Test (blows per foot)
Grab Sample	No Recovery	Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.		(PID)	Photo-Ionization Detector
				(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance				BEDROCK		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Ring Sampler Blows/Ft.	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3	< 30	< 20	Weathered
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4	30 - 49	20 - 29	Firm
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9	50 - 89	30 - 49	Medium Hard
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18	90 - 119	50 - 79	Hard
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42	> 119	>79	Very Hard
			Hard	> 8,000	> 30	> 42			

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K,L,M,N]
					Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K,L,M]
			PI plots below "A" line	MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K,L,M,P]
					Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

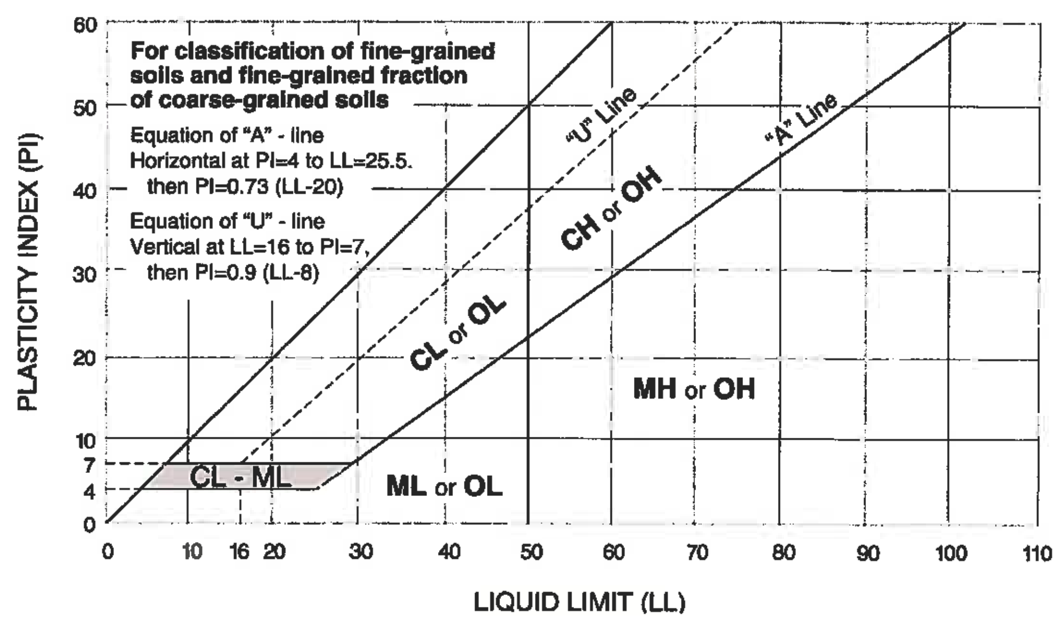


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Exhibit C-2

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) a

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

a. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.